# influence of road surface characteristics on rolling resistance

Authors:

dr. G.J.van Blokland, M+P (NL),

ir. W. Schwanen, M+P (NL)

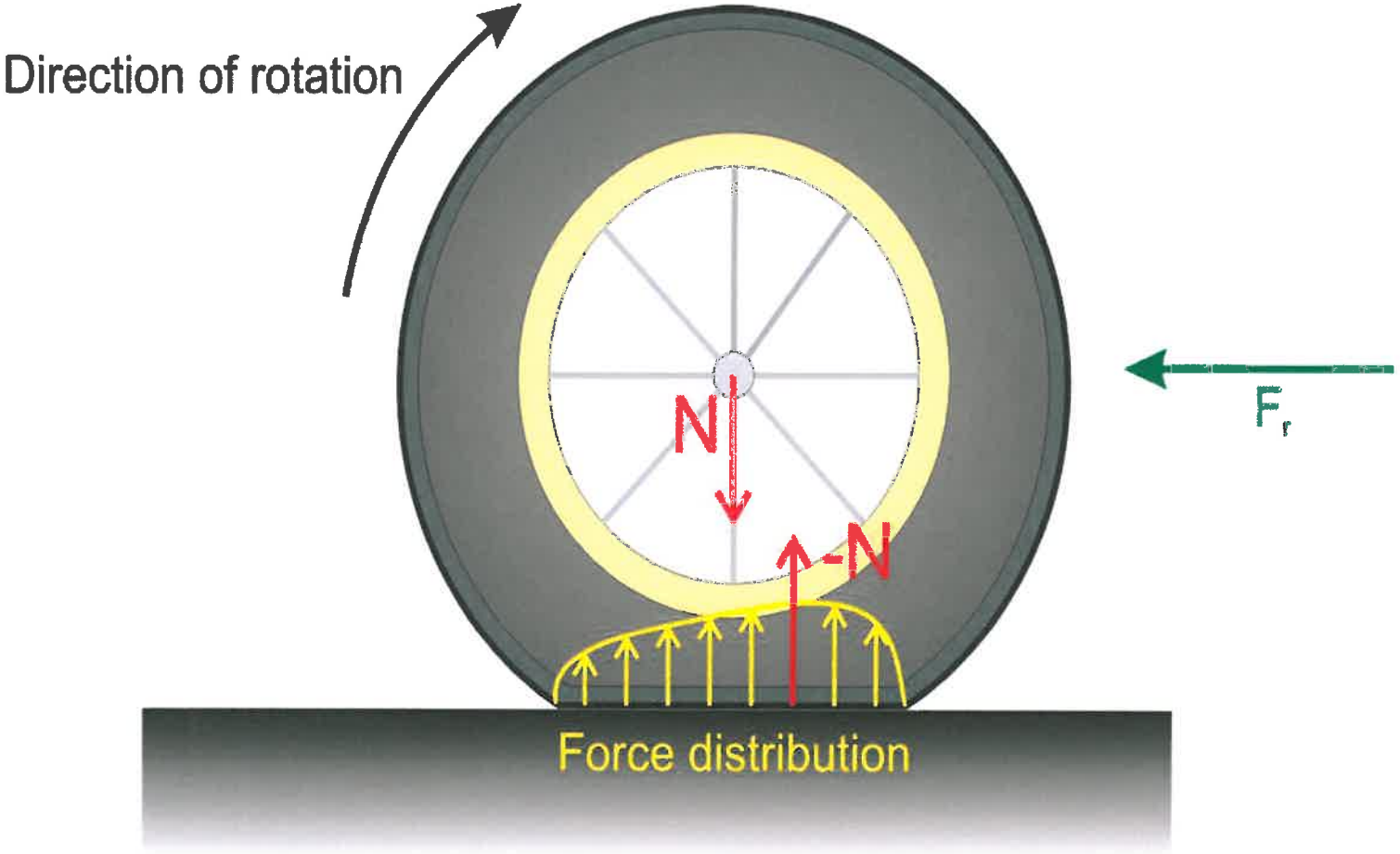
S.W. Boere, student TU/e (NL)

MBBM
MÜLLER-BBM GRUPPE

# Tentative study on effects of different road surfaces on rolling resistance and the relation with rolling noise and wet grip

- Test program
  - test procedure
  - road surface types
  - measurement results
- Rolling resistance explained with surface characteristics
  - road surface texture
  - road surface mechanical impedance
- Relation of rolling resistance with
  - wet grip
  - rolling noise

# Rolling resistance



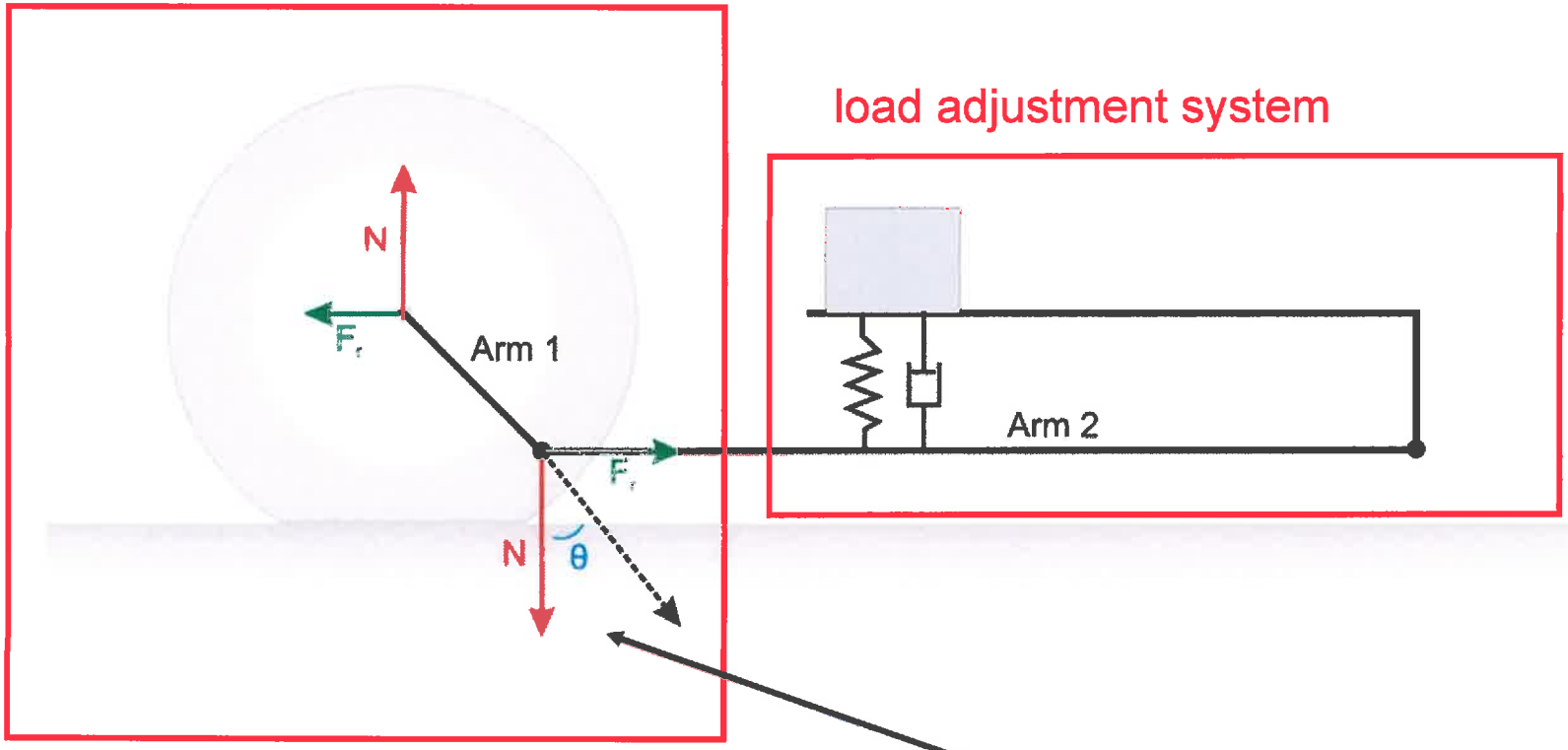
# Test vehicle

- Designed and operated by TU Gdansk

# Test vehicle: Schematic representation

direct measurement system

load adjustment system




$\theta$ : orientation of Arm 1

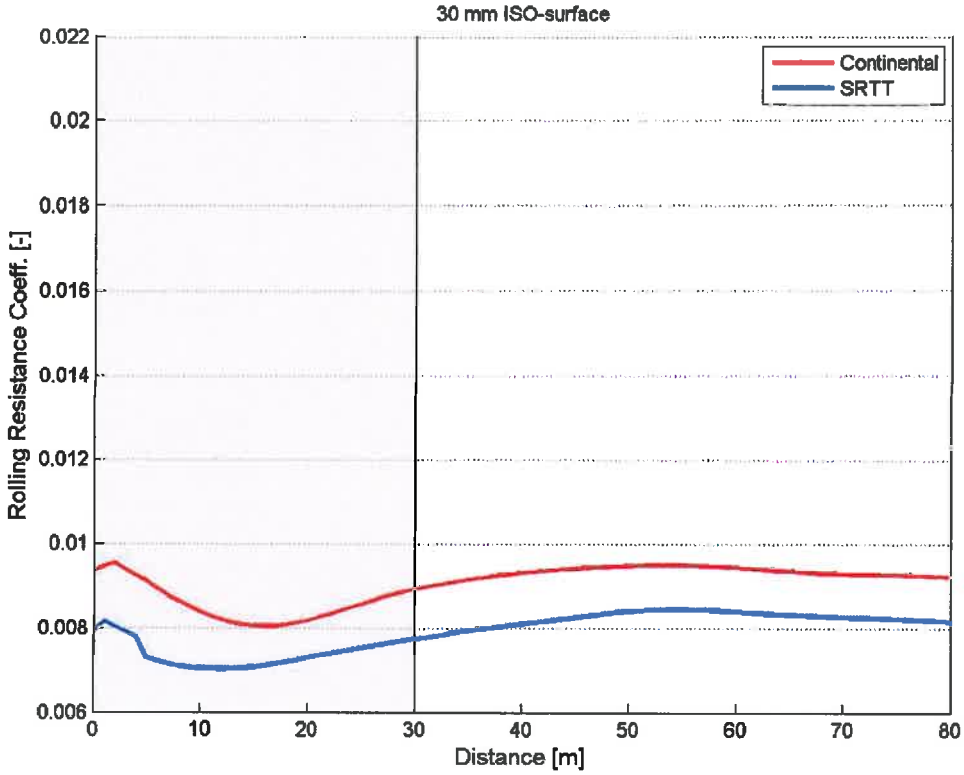
$$RRC = \frac{F_r}{N} = \tan(\theta)$$

# Test surfaces

- Kloosterzande test track in the Netherlands
- 40 different test tracks
  - ISO 10844
  - SMA (0/6, 0/8, 0/11 and 0/16)
  - Dense Asphalt Concrete 0/16
  - Semi-porous thin layered surfaces
  - Porous Asphalt Concrete with various stone-sizes and layer thickness
  - two-layer Porous Asphalt Concrete with different stone-sizes and layer thickness
  - eight experimental rubberized surfaces
  - two surface dressings

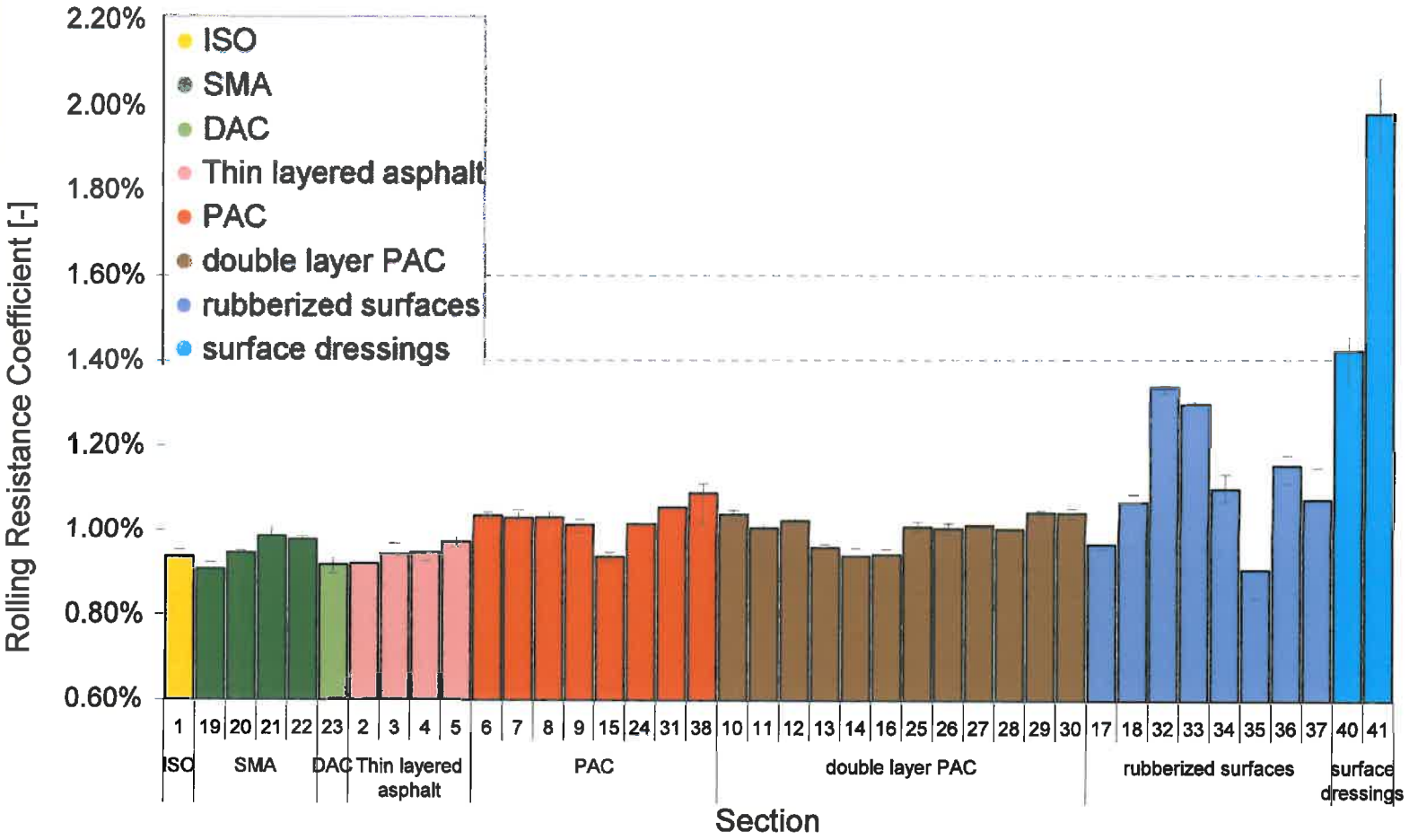
# Typical result

- Rolling resistance level as function for distance
- Grey area is dominated by transient effects
- two different tyres
  - Uniroyal Tigerpaw (SRTT) 225/60 R16
  - Continental CPC2 LI98 225/60 R16



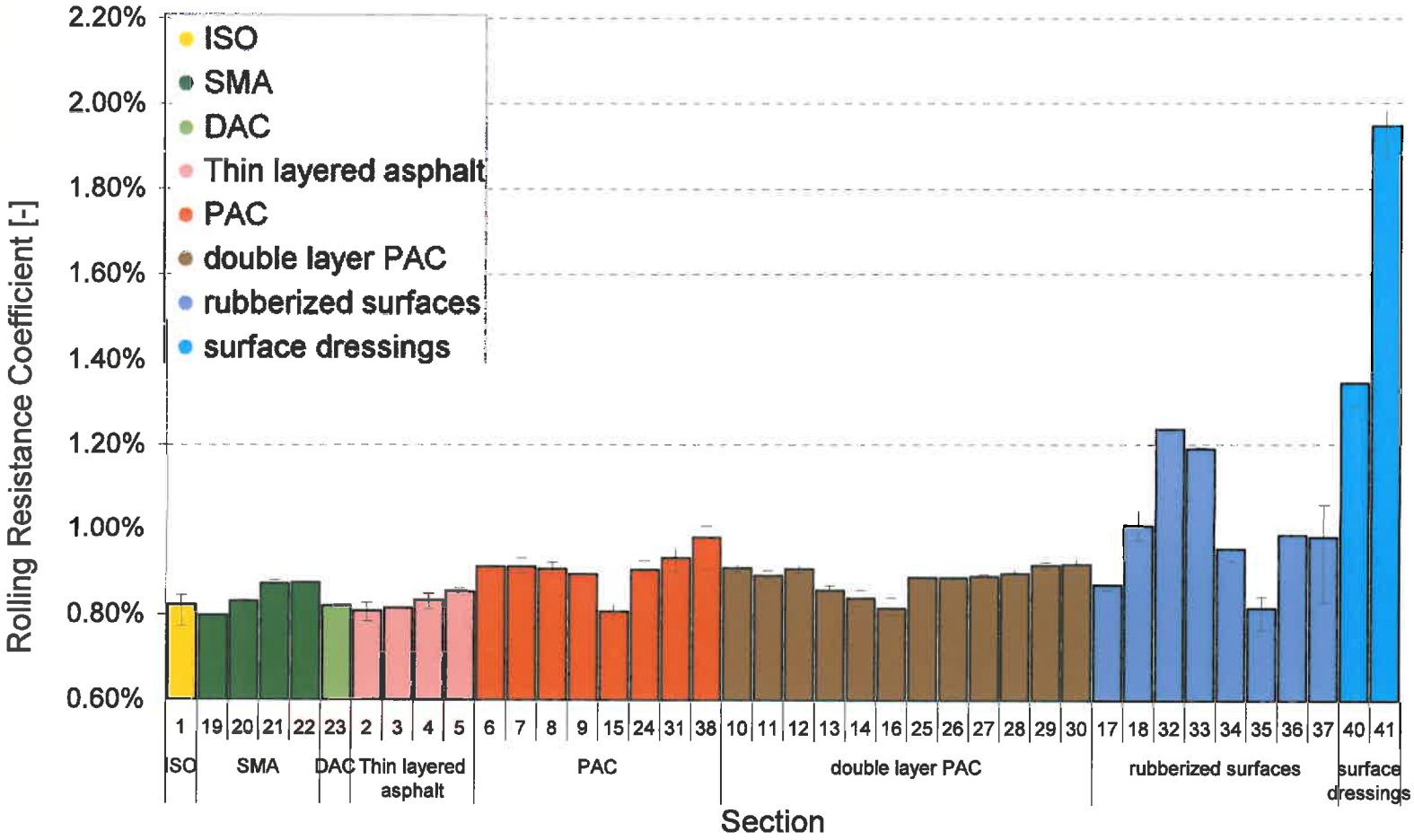
# Test results: average rolling resistance

- Results for Continental tyre in categorical sequence (average over 5 measurements)
- Error bars indicate peak-to-peak levels



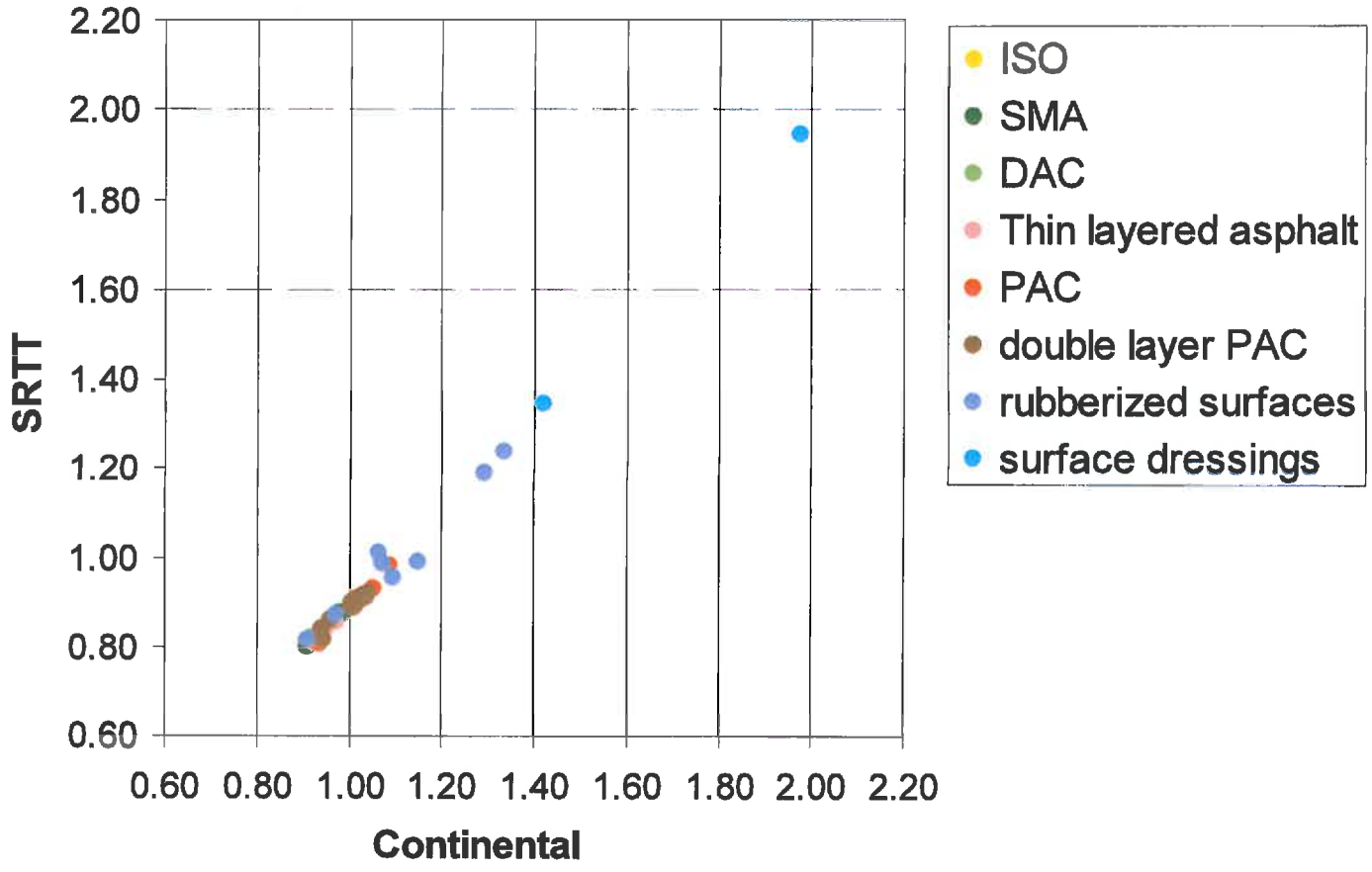
# Test results: average rolling resistance

- Results for SRTT tyre in categorical sequence (average over 5 measurements)
- Error bars indicate peak-to-peak levels



# Test results: comparison between tyres

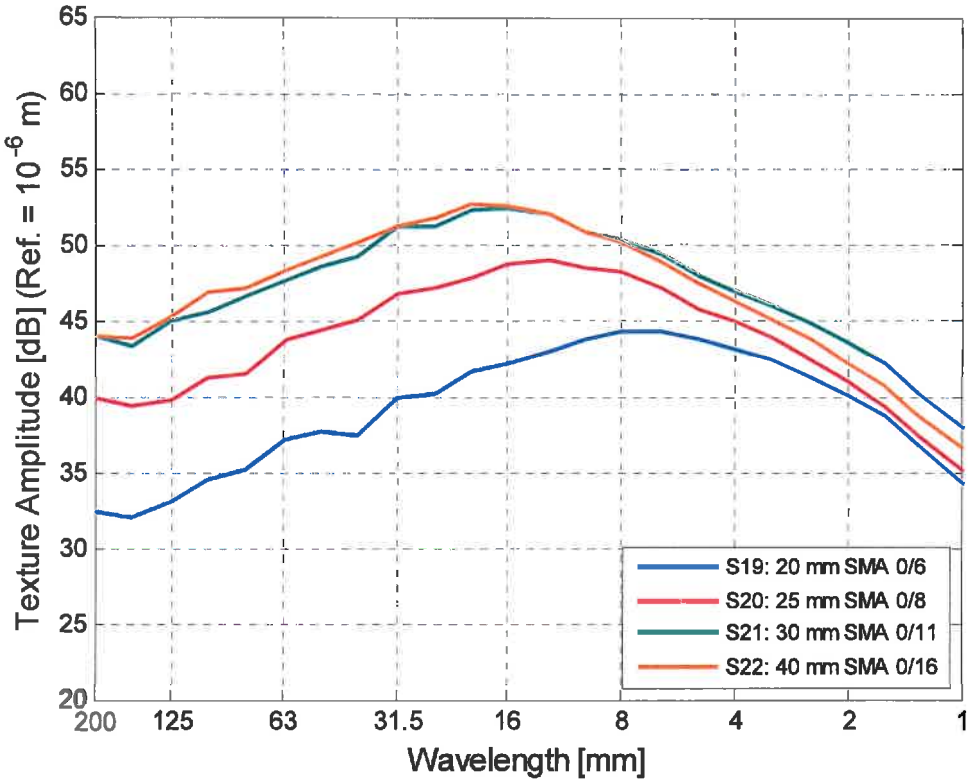
- scatter diagram of rolling resistance results of both tyres
- positive correlation : $R^2$ = 0.99, slope = 1.07, residue = 0.02,






MBBM
MÜLLER-BBM GRUPPE

# Surface texture




**3-D laser profilometer:**

- 2.95 x 0.3 m area
- 0,3 mm step and 20 µm resolution

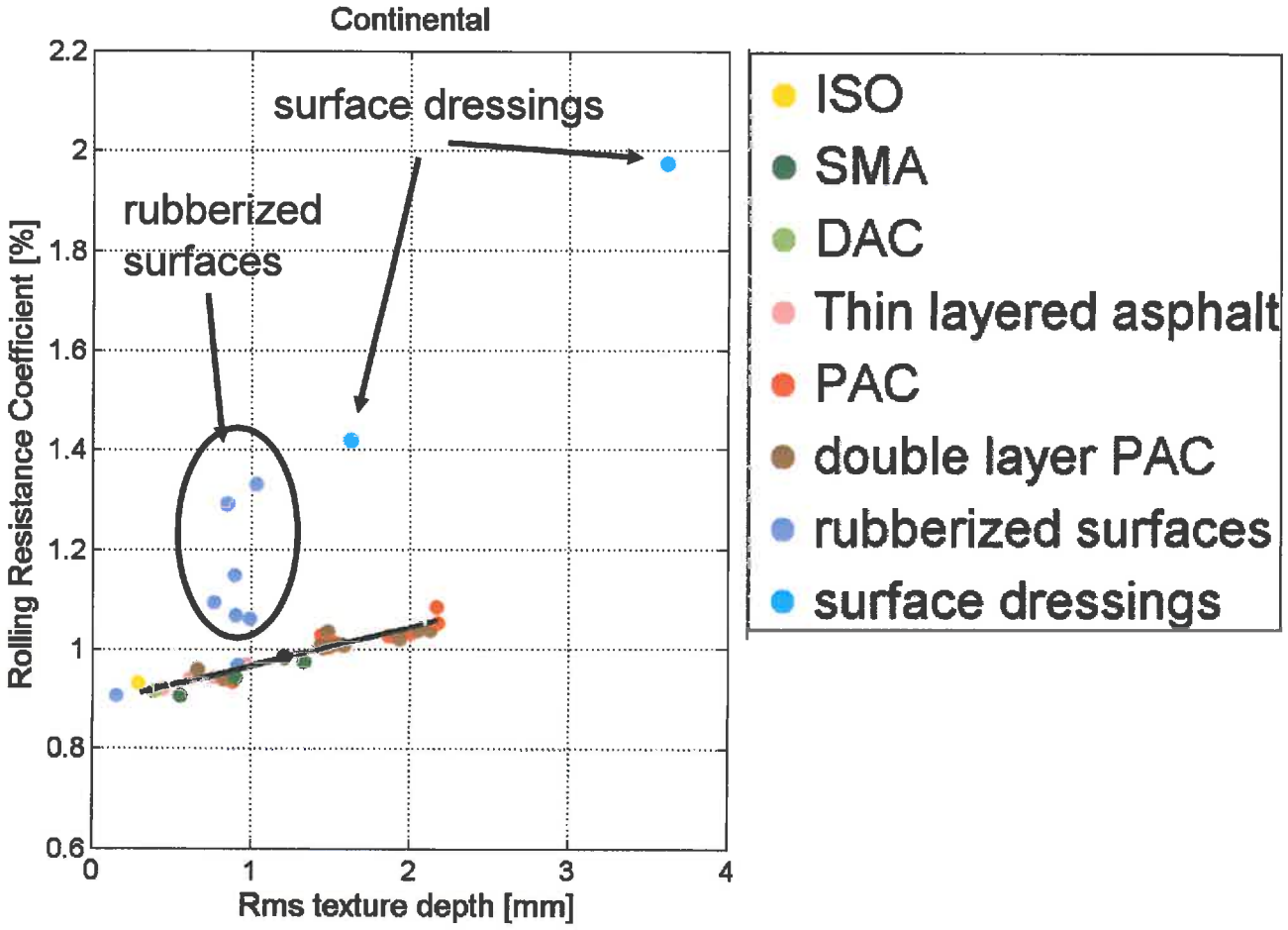
*rms* = effective amplitude of surface texture

| | rms |
|---|---|
| SMA 0/6 | 0.53 |
| SMA 0/8 | 0.88 |
| SMA 0/11 | 1.16 |
| SMA 0/16 | 1.37 |



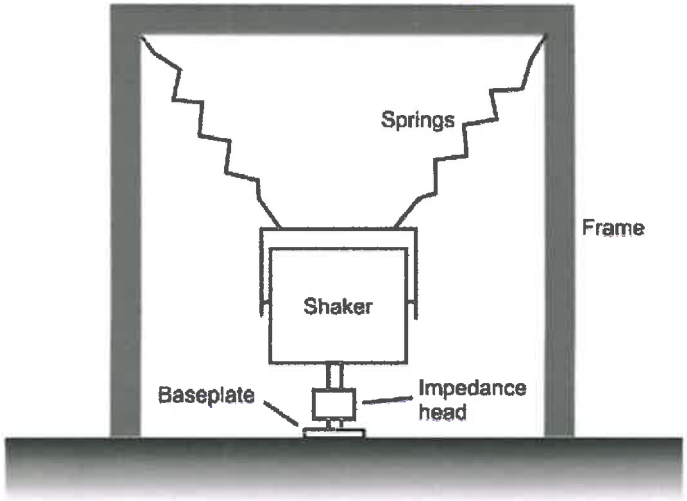
MBBM
MÜLLER-BBM GRUPPE

# Surface texture and rolling resistance




- Correlation between rms of surface texture and rolling resistance coefficient. Various colors indicate the surface types, slope =0.078 %/mm , $R^2$ =0.89 , residue = 0.016

# Mechanical Impedance : measurement principle




- harmonic excitation :

  $F(t)=F_0*sin(2\pi f*t)$

- result
  - stiffness of road surface
  - admittance

- measurement in lab
- frequency range 125 – 4 kHz
- presented result is an average over 20 excitations

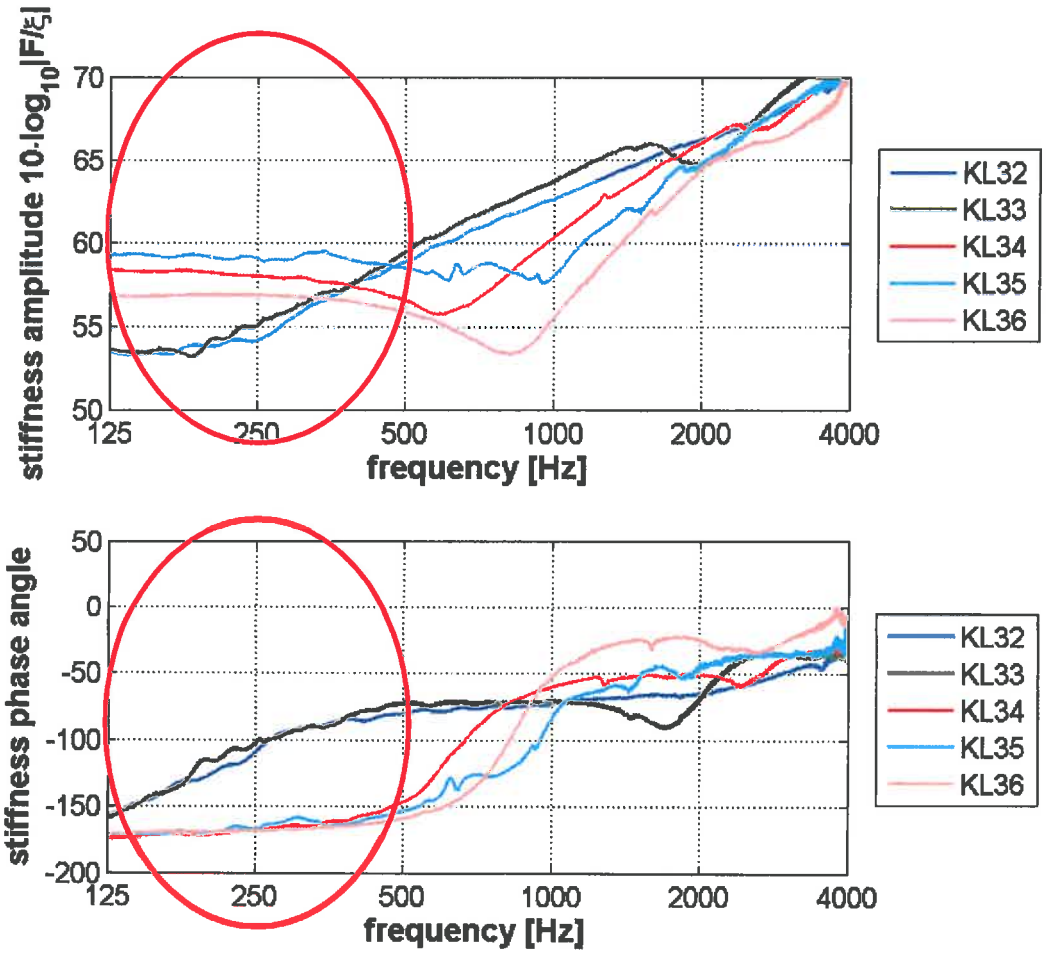
- rolling resistance:

  frequency range of interest :

  250 – 400 Hz

# Mechanical impedance

differences in mechanical behavior of flexible surfaces in frequency area relevant for rolling resistance

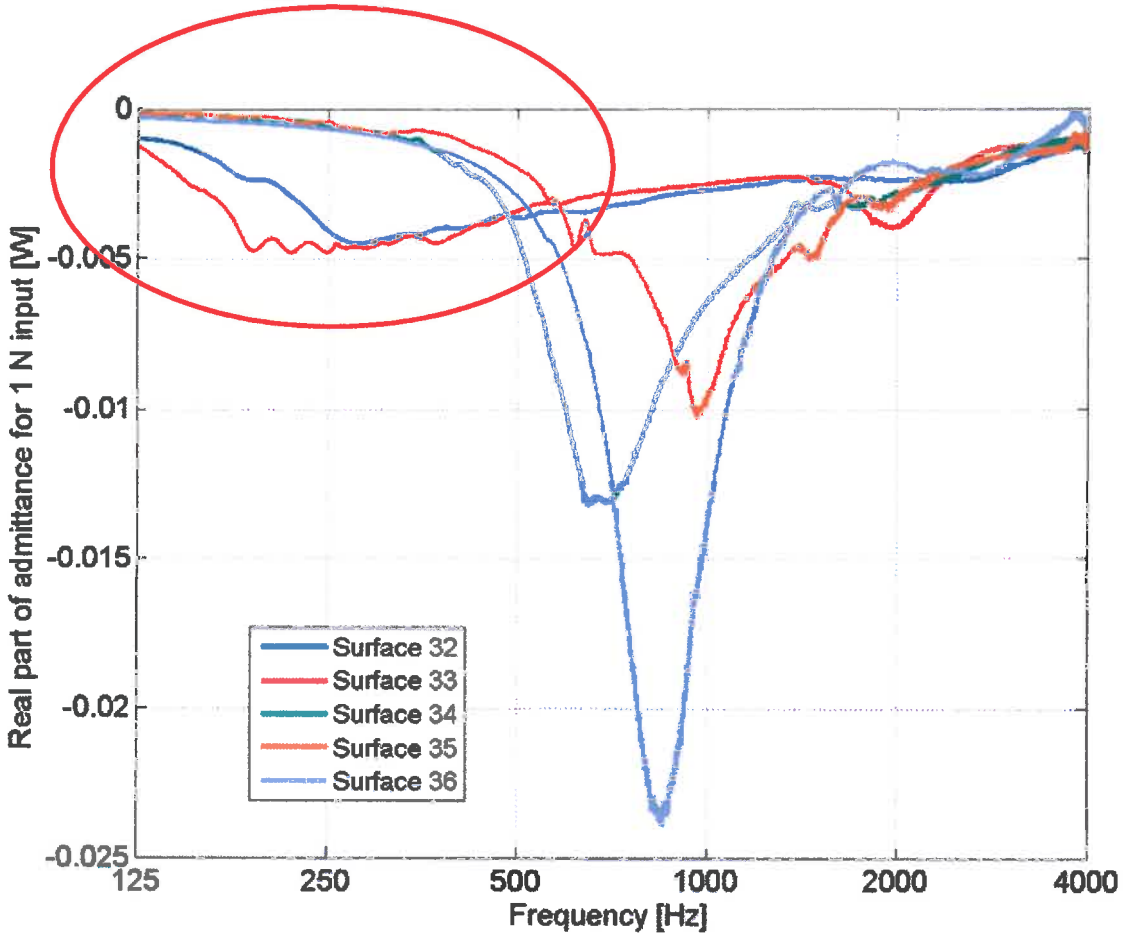


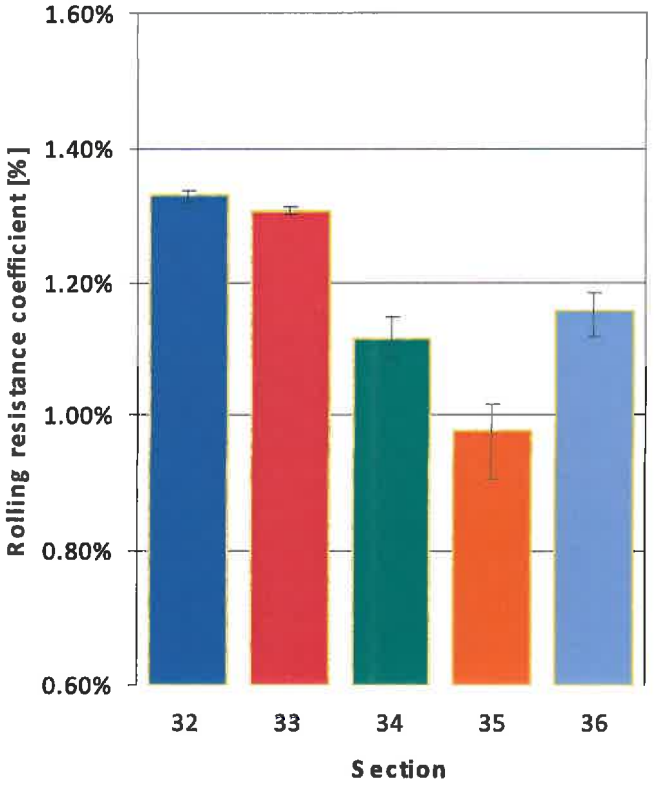



MBBM
MÜLLER-BBM GRUPPE

# Rolling resistance and mechanical impedance

- influence of damping on rolling resistance ?
- part of the differences explained by difference in damping



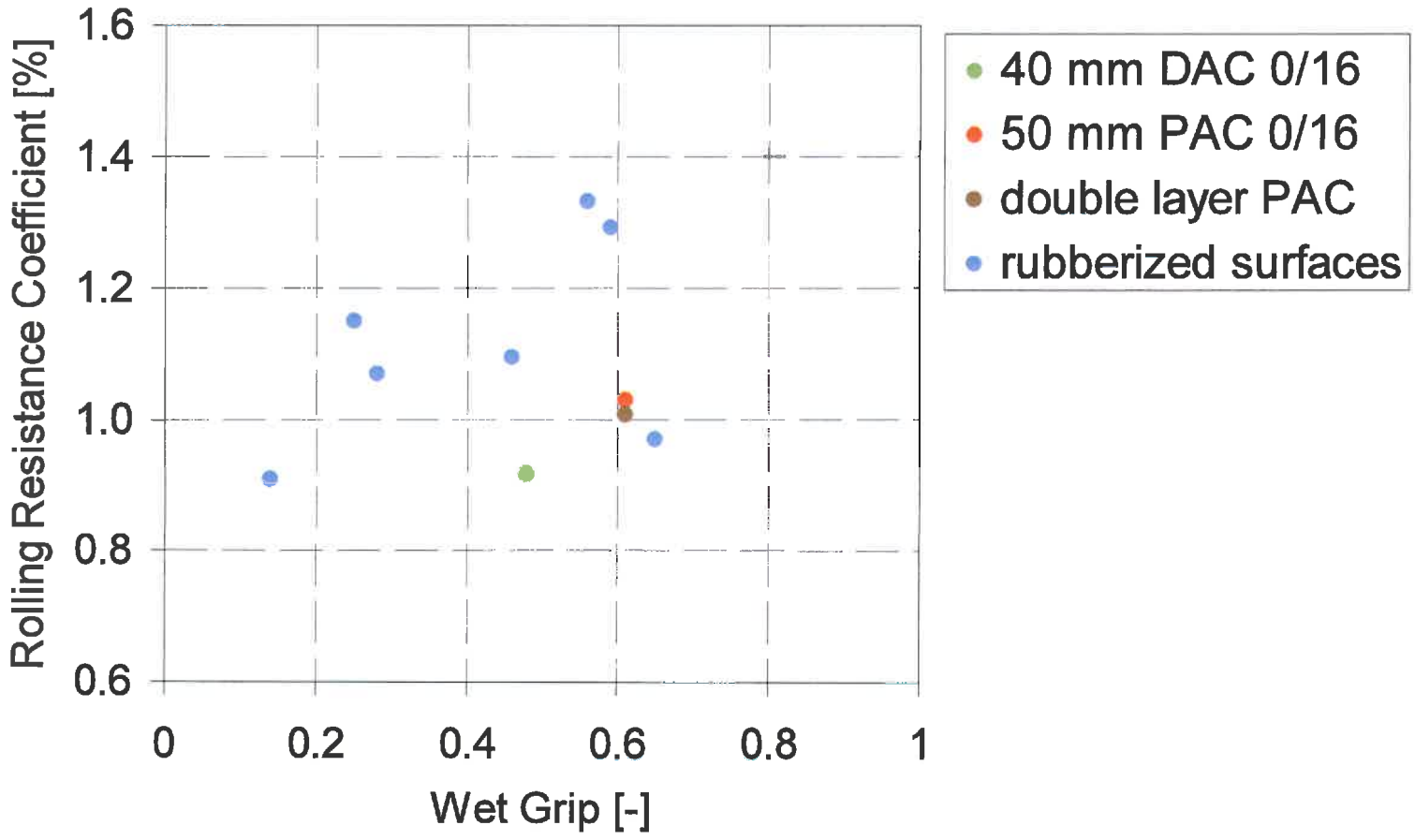





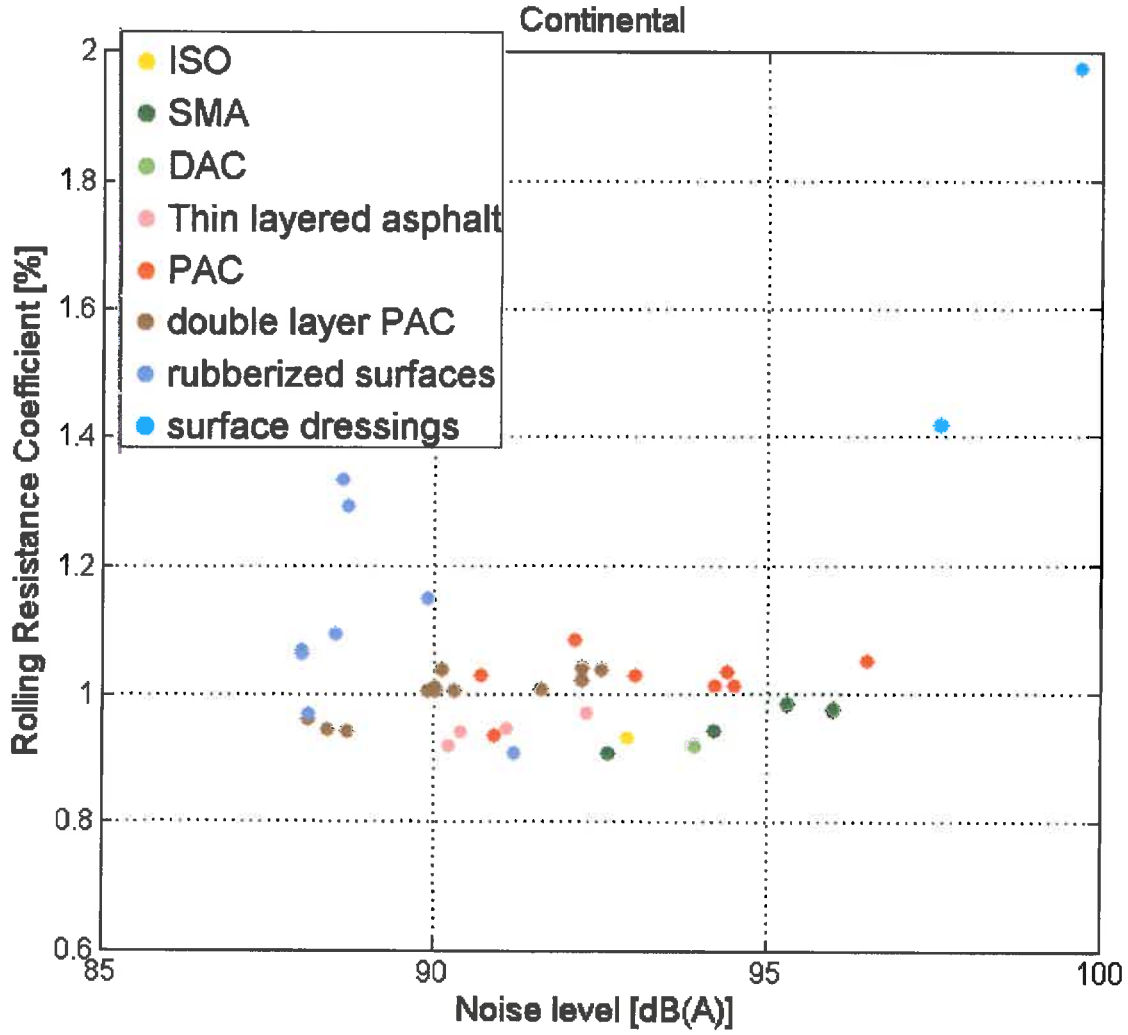

MBBM
MÜLLER-BBM GRUPPE

# Rolling resistance and wet grip

results of ten surfaces including rubberized surfaces



# Rolling resistance and tyre/road noise



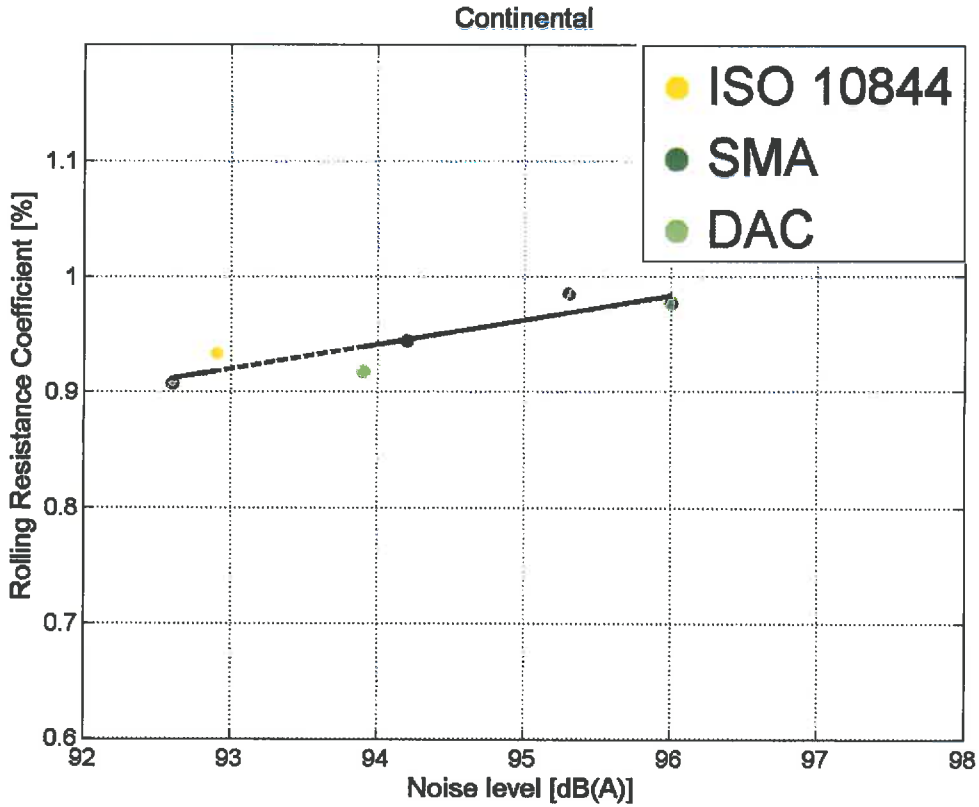



MBBM
MÜLLER-BBM GRUPPE

# rolling resistance and tyre/road noise

## subset of dense surfaces

- relation on previous sheet spoiled by effect of acoustic absorption and elasticity
- subset of test sections with no absorption and high mechanical impedance




*slope = 0.21 [%/dB]*

*$R^2$ = 0.79*

*residue = 0.14*

# Conclusions

- Road Surface Characteristics
  - good correlation between rms of texture profile and rolling resistance
  - outliers are surface dressings and elastic rubberized surfaces

- Rubberized surfaces
  - the real part of the admittance measure for energy dissipation
  - in relevant frequency range (250 – 400 Hz) higher energy dissipation corresponds to higher rolling resistance

- Effect of rolling resistance of road surfaces
  - In this study we found no correlation between wet grip and rolling resistance for road surfaces
  - For dense surfaces a positive correlation between rolling noise and rolling resistance was found

## Recommendations

- It shall be generally acknowledged that road surface characteristics have a significant effect on the rolling resistance of tyres
- Improving sustainability of road transport shall therefore incorporate both acoustic and fuel efficiency properties of road surfaces
- Measurement methods, test procedures and evaluation criteria are required for large-scale implementation
- Integrated study's on the basic interaction process between tyre and road incorporating safety effects, shall be initiated on short notice